IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Olivier RAYSSAC

Patent No.: 7,056,809 B2

Patent Date: June 6, 2006

For: METHOD FOR ION TREATING A SEMICONDUCTOR MATERIAL FOR SUBSEQUENT BONDING

Confirmation No.: 6283

Application No.: 10/695,938

Filing Date: October 30, 2003

Attorney Docket No.: 4717-7900

REQUEST FOR CERTIFICATE OF CORRECTION UNDER 37 C.F.R. § 1.323

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Patentee hereby respectfully requests the issuance of a Certificate of Correction in connection with the above-identified patent. The corrections are listed on the attached Form PTO-1050. The corrections requested are as follows:

Column 10:

Line 28 (claim 6, line 2), after "the plasma are Si and SF_6, SiC and SF_6/O_2," insert -- SiO_2 --. Support for this change appears in application claim 7.

Line 58 (claim 14, line 5), after "clusters that is directed to" delete "is directed to". This change is requested merely to correct a clerical error.

Column 11:

Line 9 (claim 17, line 4), after "controlled number of" delete "ion sin" and insert -- ions in --. Support for this change appears in application claim 18.

A fee of $100 is believed to be due for this request. Please charge the required fees to Winston & Strawn LLP Deposit Account No. 50-1814. Please issue a Certificate of Correction in due course.

Respectfully submitted,

2-7-07
Date

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212-294-3311

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO.: 7,056,809 B2
APPLICATION NO.: 10/695,938
DATED: Jun. 6, 2006
INVENTOR(S): Rayssac

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 10:
Line 28 (claim 6, line 2), after "the plasma are Si and SF_6, SiC and SF_6/O_2," insert -- SiO_2 --.
Line 58 (claim 14, line 5), after "clusters that is directed to" delete "is directed to".

Column 11:
Line 9 (claim 17, line 4), after "controlled number of" delete "ion sin" and insert -- ions in --.

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An interesting application of this consists in using as layer **20** wafers whose surface condition is incompatible with bonding via molecular adhesion (roughness greater than a value of about 5 Angstroms rms), to treat certain regions of these wafers so as to smoothen them and bring their roughness to a value that enables such bonding.

In particular this allows for the recycling of negatives issued from a SMARTCUT® type process, by reusing them.

And still in this case, it is possible to use layers constituted from a wafer whose intrinsic surface condition is incompatible with bonding (SiC, III-V). Instead of proceeding with the complete polishing of such a wafer, a bombardment with clusters comprising a rather large number N of ions will make it possible to smoothen the surface of the wafer.

Moreover, this smoothing can be very precisely controlled, both in terms of final roughness and in terms of creating a spatial pattern with more or less smooth regions in view of bonding.

However if the starting surface condition of the layer **20** is inferior to a given threshold R_0 (which depends among other things on the nature of the material of the layer and of the bombarded species), it will only be possible to increase this roughness.

Indeed, if the starting point of the curves **C'1** to **C'5** happened to be below the threshold R_0 (whereas it is situated at the level of this threshold in FIG. **2***b*), it would not even be possible to retain this starting low roughness by proceeding with a bombardment of the surface: even a bombardment with a very great value of N would result in an increase of the roughness.

Now in reference to FIGS. **4***a* to **4***c*, they schematically represent layers **20** having been subject to a bombardment with ion clusters such as described above, during which the roughness of certain regions of the surface of the layer has been selectively modified.

FIG. **4***a* thus represents a layer on the surface of which a ring has been created with a roughness lower than that of the rest of the surface, so as to obtain a greater mechanical stability on this ring at the time of assembling the layer **20** with another layer (homogeneously smooth for example).

Thanks to the programming of the means of displacement **107**, it is possible to create on the surface of the layer, any other desired pattern. FIGS. **4***b* and **4***c* thus respectively represent a layer **20** with a grid pattern, and with a paved pattern, with a roughness lower than that of the rest of the surface of the layer.

And by controlling the number N of ions in the bombarded clusters in conjunction with the displacement of the layer **20**, it is thus possible to create any pattern, including with several levels of roughness selectively distributed over different desired regions of the surface of the layer.

It is then possible to create patterns with variable roughness, to constitute detachable substrates whose distribution of roughness over the surface is perfectly controlled.

The expression "pattern with variable roughness" designates a pattern of which different zones may have different roughness.

It is to be noted that the implementation of the invention thus allows for the very fine controlling of the levels and distributions of roughness on the surface of a layer from which a detachable substrate is to be created after the reversible bonding via molecular adhesion with another layer (whose roughness may have been adjusted if necessary).

It is also to be noted that the fact of proceeding with a bombardment with ion clusters only modifies the surface of the layer **20**, no subsurface damage being engendered by such a bombardment. In this regard reference can be made to the article "Substrate smoothing using gas cluster ion beam processing" by Allen and al., Journal of Electronic Materials, Vol.30, N°7, 2001.

What is claimed is:

1. A method for treating a semiconductor material for subsequent bonding which comprises bombarding a surface of the semiconductor material with a beam containing a controlled number of ions in ion clusters to etch a pattern in the surface with the beam, wherein the number of ions is controlled to provide a desired roughness of the surface pattern to improve adhesion during subsequent bonding; and bonding the surface of the semiconductor material to a surface of a semiconductor substrate to form a detachable substrate structure.

2. The method of claim **1**, wherein the ions comprise chemically inert species in relation to the semiconductor material.

3. The method of claim **2**, wherein the semiconductor material is made of at least one of silicon or silicon carbide, and the ions are argon ions or nitrogen ions.

4. The method of claim **1**, wherein the surface is bombarded with ions that are capable of chemically reacting with the semiconductor material.

5. The method of claim **4**, wherein the ions are generated from a plasma.

6. The method of claim **5**, wherein the surface layer and the plasma are Si and SF_6, SiC and SF_6/O_2, ~~and SF_6/O_2,~~ SiO_2 SiO_2 and CHF_3/SF_6, Si_3N_4 and $CHF_3/O_2/SF_6$, respectively.

7. The method of claim **1**, wherein the number of ion clusters bombarding the surface is controlled to smooth the surface to a roughness value suitable for molecular bonding.

8. The method of claim **7**, which further comprises controlling the number of ions bombarding the surface by controlling the pressure of an ion source that generates the ion clusters.

9. The method of claim **1**, which further comprises controlling an acceleration voltage that is applied to the beam to control the speed of the ion clusters and the resulting etching of the surface.

10. The method of claim **1** which further comprises directing the ion clusters to selectively treat desired zones of the surface to create an adjusted pattern thereon.

11. The method of claim **1** which further comprises focusing the beam such that the ions, any monomer species of the ions, and the ion clusters are directed towards a portion of the surface of the semiconductor material to cause etching thereof.

12. The method of claim **11** which further comprises directing the beam of ion clusters to a selected impact site on the surface of the semiconductor material.

13. The method of claim **12**, wherein the semiconductor material is moved to provide the desired pattern.

14. A method for treating a semiconductor material for subsequent bonding which comprises

bombarding a surface of the semiconductor material with a beam containing a controlled number of ions in ion clusters that is directed to ~~is directed to~~ a selected impact site on the surface of the semiconductor material to etch a pattern in the surface with the beam by moving the semiconductor material to provide the desired pattern, wherein the number of ions is controlled to provide a desired roughness of the surface pattern to improve adhesion during subsequent bonding, which further comprises creating an appropriate spatial pattern on the surface that has a different roughness in comparison to other portions of the surface.

15. The method of claim **14**, wherein a plurality of patterns of variable roughness are created on the surface.

16. The method of claim **1**, wherein the semiconductor material is one that is recycled after removal of a transfer layer.

17. A method for treating a semiconductor material for subsequent bonding which comprises bombarding a surface of the semiconductor material with a beam containing a ions in controlled number of ion sin ion clusters to etch a pattern in the surface with the beam, wherein the number of ions is controlled to provide a desired roughness of the surface pattern to improve adhesion during subsequent bonding; and further wherein the semiconductor material includes at least one layer of a material that is different than the semiconductor material, with the layer providing the surface of the semiconductor material that is etched by the bombarding.

18. The method of claim **17**, wherein the semiconductor material includes at least two layers of materials that are different than the semiconductor material, with the outermost layer providing the surface of the semiconductor material that is etched by the bombarding.

19. A method for treating a semiconductor material for subsequent bonding which comprises:

bombarding a surface of the semiconductor material with a beam containing a controlled number of ions in ion clusters to etch a pattern in the surface with the beam, wherein the number of ions is controlled to provide a desired roughness of the surface pattern to improve adhesion during subsequent bonding; and

controlling the number of ions bombarding the surface by controlling the pressure of an ion source that generates the ion clusters, or controlling an acceleration voltage that is applied to the beam to control the speed of the ion cluster and the resulting etching of the surface.

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